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Abstract
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Keywords
Africa, Ghana, mortality, morbidity, children, death, disease, infectious diseases, household conditions, hygiene, health, housing, water, toilets, sanitation, sanitation facilities, water facilities, household sanitation, diarrheal diseases, malaria, seasonality of mortality, developing countries, infant mortality, childhood mortality, maternal education, maternal literacy, education status, water source, Ghana Supplementary Enquiry, data, survey, schooling, educational attainment, water sanitation, death rates, deaths, causes of death, risk of death, births, infectious diseases, parasitic diseases, rural, urban, piped water, residence, place of birth, religion, employment status

Comments
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The Relationship Between the Level of Household Sanitation and Child Mortality -An Examination of Ghanaian Data-

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This paper examines the relationship between sanitation and the risk of child mortality in Ghana in 1971. In addition to using the presence or absence of toilet and water facilities in the home as an indicator of sanitation, combinations of the types of toilet or water facilities and the education of the mother are used. The results of the analysis show that although better facilities(for example, piped water, water closets or private latrines) are often associated with lower child mortality, the advantages of better sanitation facilities are severely limited when mothers are not educated. Providing as little as one to six years of formal education results in considerable reductions in child mortality risks even among mothers using poor water and toilet facilities, and the combination of some education and adequate facilities appears to reduce substantially the risk of death.

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1.BACKGROUND

Poor water and toilet sanitation have been found to be associated with high child morbidity and mortality in a variety of locales (Gordon et al., 1964b; Rowland et al., 1978; Barrell and Rowland, 1979). One of the more dominant relationships which has been documented is that between the incidence of diarrheal disease and the quality of water and toilet facilities. An important cause of deterioration in water quality is fecal contamination. Gordon et al. (1964), for example, argue that the immediate source of infection common to all forms of diarrhea is feces-contaminated water. The incidence of cholera in rural Bangladesh was also found to be associated with the use of polluted water (Khan et al., 1981).

The association of feces and water in the causation of various diseases is made clear from a definition of "water-washed diseases" provided by Cairncross et al. (1981) and discussed by Cutting and Hawkins (1982). " Waterborne diseases" are those resulting from infection by a pathogen whose major habitat for an essential part of its life is water. Such diseases include schistosomiasis and guinea worm infection. " Water-washed" and "water-based" diseases, on the other hand, are the result of contamination by some other matter--frequently feces--using water as a vector. This class of diseases includes typhoid, dysentery, infectious diarrheas and infectious hepatitis,which are all primary killers of young children in less developed

countries (Stein, 1977). Cutting and Hawkins (1982) note that the transmission of such diseases depends on the existence of a fecal-oral route or a channel which permits the transmission of the contaminating agent into the body. It should be noted that apart from water, food and cooking utensils could also serve as important vectors for transmitting contaminants. Rowland et al. (1978),for example, found fecal contamination of weaning foods and utensils in the Gambia to be a persistent threat to child health. Among the strategies which Cutting and Hawkins propose to eliminate the fecal-oral route are washing and other hygienic measures which would eliminate contamination at the source; the provision of uncontaminated water and food; and improved facilities for human waste disposal. For purposes of maintaining hygiene to eliminate contaminants, it may be presumed that the availability of adequate quantities of water would also be important. As noted by Stein (1977), while some water-related diseases spread as a result of using polluted water, others spread because of shortages in water and the subsequent development of poor sanitary habits.

Thus it would appear that the provision of modern sanitary facilities might go a long way toward reducing morbidity and mortality in many parts of the world. However, availability of better waste disposal facilities and improvements in water quality have not always lowered child morbidity and mortality. Studies by Levine et al. (1976) and Curlin et al. (1977), for example, have shown no reduction in the incidence of primary

water borne diseases with the provision of unpolluted water. Scrimshaw et al. (1968) also found situations where the construction of toilets had little effect on the prevalence of disease.

An important factor which has been suggested as a mitigating influence on the advantages of better sanitation facilities is poor, unhygienic usage habits. Gordon et al. (1964), for example, argue that education and the proper use of sanitation facilities are essential components of sanitation programs. They note that "the provision of sanitary facilities is the means to an end and not the basic consideration." It would thus be expected that translation of the availability of high quality water and toilet facilities into improved levels of sanitation in the home would depend on the way these facilities are used. In essence, the gross level of sanitation within the home is not dependent only on the presence or absence of facilities. Definitionally, "sanitation facilities" aid in the maintenance of sanitary conditions but are in themselves not an accurate indicator of the true level of household sanitation.

Studies have, however, often used the presence or absence of toilet facilities in the home as an indicator of the level of sanitation (Greenland et al., 1981; Butz et al., 1982). If a better measure of sanitation is the quality of facilities adjusted for differences in usage habits, then a more accurate sanitation index should be a variable which combines both availability and usage factors in the home. While some data sets which gather information on child mortality contain information

on the type of toilet or water facilities available to the household, none known to the author contains information on health related attitudes and practices or information on the observance of basic hygiene. Many data sets include some measure of maternal education or literacy--attributes which may be indicators of the practice of hygiene (Meegama, 1980; O'Hara, 1980). Meegama (1980), for example, considers maternal education as an indicator of a mother's "level of understanding of hygiene and health care." If mother's education is accepted as such an indicator, then a more accurate measure of the level or extent of sanitation in the home could be derived from a combination of mother's education status and the quality of sanitation facilities available to her household.

This paper examines the relationship between two such sanitation variables and child mortality in Ghana. The two variables examined combine mother's education status and toilet facility, and mother's education and water source. Although the overall extent of sanitation would probably be more completely represented by a variable which groups women on the basis of three variables --i.e., education, toilet and water facilities--this paper uses two separate measures. The quality of water sanitation is approximated using a combination of mother's education and her primary source of water. Similarly, a measure of toilet sanitation is derived by combining mother's education with the type of toilet used by her household.

2. THE DATA

The data used for this analysis are from the Ghana (1971) Supplementary Enquiry which was a 5-percent stratified sample survey of the population. Fairly detailed household-level data were gathered including information on the type of toilet used, the main source of water, type of kitchen and bathroom facilities and the materials used in the construction of the dwelling unit. Data on child mortality are derived from traditional Brass-type questions on the numbers of children born and surviving. The other individual-level variable of direct interest to the study is mother's education.

For most parts of the analysis here, a gross distinction is maintained between educated and uneducated mothers. "Educated mothers," as defined for the study, are those who have successfully completed at least one year of formal schooling while "uneducated mothers" have not. Where comparisons are made between different levels of education,they indicate the highest level of formal schooling at which a grade was completed. This is because, as coded by the Ghana survey, individuals are placed into broad levels based on the actual reported years of schooling "attained". For example, a woman coded into the "primary education level" category may have completed between 1 and 6 years of schooling. Therefore, women classified into a specified level may, in fact, differ widely in the actual amount of schooling they have completed. In this study, analysis by levels of education is performed

mainly to ascertain whether the results obtained when mothers are separated into "educated" and "uneducated" also apply across broad educational groupings.

Data from the Ghana survey are particularly suited to this analysis since detailed classifications of both water sources and toilet types are given. Six different types of toilet and ten sources of water are identified. Toilet types include modern flush, private and public pan latrines, private and public pit latrines and "others". The "others" category implies the absence of any toilet facility and, thus, a resort to bushes, rivers or the outskirts of the village or town. The ten sources of water include pipe in the home, pipe outside the home, rainwater in a tank in the home, well in the house, public well, public dam, public borehole with a pump, stream or river, lake or pond, and others not specified (see Appendix 1). Although child mortality differentials exist across the detailed water-source categories, most of the analysis will focus on the distinction between the mortality experiences of women using piped and non-piped water. This broad distinction is particularly necessary in the creation of the "water sanitation" variable. Since this variable is a combination of a mother's educational status and the primary source of water, twenty categories would have been necessary if all types of water were maintained. The five toilet types, however, are not recoded in the construction of the toilet sanitation variable. (See detailed codes of sanitation variables in Appendix 1.)

3. METHODOLOGY

There are two parts to this analysis. The first is an examination of child mortality differentials across subgroups of mothers who use different toilet and water facilities. Child mortality indexes, computed as ratios of the level of child mortality of the subgroup to the average child mortality experience of all women, are compared. The relationship between the type of facility used and child mortality is examined in an ordinary least squares (OLS) regression model which controls for several other attributes of mothers which could influence the mortality of their children. In the second part of the analysis, the relationship between the sanitation variables--which combine quality of facility and mother's education--and child mortality is examined.

The analysis is based on the method derived by Trussell and Preston (1980) to convert answers from traditional Brass-type questions on "children ever born" and "children surviving" into statistically sound estimates of the risk of child mortality for use in multivariate analysis. A basic component of their method is the computation of the "expected number of deaths" among children ever born to mothers in specified marital duration or age groups. The expected number of deaths (E_i) to women of marital duration d for example, is computed as:

$$E_i = \sum_d B_i(d) * PD^s(d)$$

where $B_i(d)$ is the number of children ever born to women in the ith cell of marital duration d ;

and $PD^s(d)$ is the standard expected proportion dead among children ever born to women in marital duration **d**.

The standard expected proportion dead is computed by inverting the Brass formula for converting proportions dead among children ever born by marital duration or age of mother into life table estimates of child mortality. The result is:

$$PD^s(d) = q^s(a)/K^s d$$

where $q^s(a)$ is the life table probability of dying by age a from a standard mortality function;

and $K^s(d)$ is a multiplier that depends on the average parities of women in marital durations 0-4, 5-9, and 10-14 years.

Based on the assumption that age functions of the cumulative probability of dying since birth are proportional to the standard imposed by the investigator, the index of mortality **k** is estimated as the observed number of deaths divided by the expected number of deaths. This ratio, which can be computed either for each individual woman with one or more live births or for sub-groups of women, is then the dependent variable to be entered in the multivariate analysis.

Marital duration rather than maternal age is used as the index of the duration of exposure of children in this analysis. Child mortality refers to the mortality among children ages 0-4 years and corresponds to the child mortality experience of mothers who have been married 0-14 years. The set of q(a) values for level 12 of the Coale-Demeny (1966) North model life tables was chosen as a standard in computing the expected number of

deaths. The implied level of life expectancy at birth is 47.5 and 44.3 years for females and males, respectively, and is comparable with a joint life expectancy of 44.6 years estimated using the same data (Tawiah, 1979). In computing the child mortality indexes in Table 1, the same procedure was followed except that a single value of expected number dead was computed for the entire sample of mothers. The formula used to compute the index is:

$$\text{Index } (k) = \frac{\sum_{ij} CD_{ijk}}{\sum_{ij} CEB_{ijk}} \Big/ \frac{\sum_{ijk} END_{ijk}}{\sum_{ijk} CEB_{ijk}}$$

where END_{ijk} is the expected number of children dead to individual woman i, of marital duration j, and population subgroup k;

and CD_{ijk} and CEB_{ijk} are the numbers of children dead and children ever born, respectively, to woman i, of marital duration j, and population subgroup k.

The ratio in the denominator sums across individuals, marital durations and subgroups of the population and thus has a constant value regardless of the subgroup under consideration. Thus, the numerator of the index is the proportion of children dead among children ever born to women in subgroup k, and the denominator is the expected proportion dead in the entire population. The computed indexes can be interpreted as the ratio of the child mortality experience of the specified subgroup to the average expected child mortality in the population. An index of 1 suggests

there is no difference between the specified subgroup and the average and an index less or greater than one suggests better or worse than average child mortality, respectively.

The attributes of mothers which are controlled for in the multivariate analysis include place of birth and current residence (each coded urban or rural), education and religion of household head, mother's labour force status and the types of bathroom and kitchen facilities used in their households at the time of interview. Because several studies have cited strong and significant differentials in child mortality associated with rural/urban residence (United Nations, 1973; Behm 1976-78) and with mother's work status (Farah and Preston, 1981; Haines and Avery, 1982) these variables are controlled in this study. In addition to rural/urban residence and mother's work status, this study controls for the types of kitchen and bathroom facilities, since child mortality differentials by water and toilet facilities may also reflect the quality of these other household facilities. It is likely, for example, that mothers who do not have piped water also do not have private, enclosed bathrooms. The control for region of residence in this study is very important since preliminary examination of the data suggested very wide child mortality differentials across regions. Children born to mothers who live in the Upper region, for example, experience three times higher child mortality than those born to mothers residing in Accra. These differentials are primarily a result of uneven distributions of health-care facilities and other infra-structure

across the regions and also probably of consequence of climatic and cultural differences.

It should be noted that in fitting all the OLS regression models reported on in the next section, mothers are weighted by the numbers of children they had ever born in order to satisfy the condition of homoskedasticity required for the OLS coefficients to be fully efficient. Further, in fitting the models to assess the relationship of the sanitation variables to child mortality, each sanitation variable is entered in a separate regression model. When a particular sanitation variable is entered into the model its components are not entered into the same model. Thus, when water sanitation--WATSAN--is entered in a model, mother's education and the source of water are not entered in the same model. However, type of toilet facility is used in the model to account for differences in the predicted coefficients that may be a result of different toilet facilities.

4. RESULTS

A. The Relationship between the type of facility used and child mortality

Water facilities: Table 1 which presents child mortality indexes for mothers classified by the type of water facility used, suggests that there are wide differences in child mortality associated with quality of facility. Among specific water sources,

the use of lakes and ponds or public dams is associated with the highest child mortality. Mothers using such water sources experience over 20 percent higher child mortality than average. The common characteristic that these water sources share is a lack of flow. Ponds, lakes and dams are stagnant and probably contain contaminants which are not diluted through flow as in streams or canals. The use of water which is piped directly into the home is associated, not surprisingly, with the lowest child mortality risk, just over one-half the average. Mothers who use public standpipes fare slightly worse with 82 percent of the average child mortality level. Differences in child mortality between the two piped water sources are probably due to fetching and storage habits. The use of public standpipes implies a need to fetch, carry over variable distances and store water. These activities may be associated with considerable risks of contamination. An alternative explanation is that mothers who use public standpipes may also be from lower socio-economic status groups.

After controlling for the available socioeconomic factors in the multivariate analysis (Table 2), mothers who use public pipes have 2.7 percent higher child mortality than those who use water piped into their own homes. However, this difference is not significant. Many of the control variables account for significant, and often large, differences in child mortality between mothers. With these controls in the analysis, the worst child mortality experience is recorded by mothers who use rainwater.

In Ghana, the collection of rainwater for domestic use typically involves the channelling of water off the tops of roofs into open tanks which may be located in the center of the compound. The risk of contamination from dirty roofs and tanks, and dirty utensils in the fetching process multiplies the possible health hazards posed by such water sources. The only water source which appears to be associated with lower child mortality than pipe-borne water in the home is "borehole." This result, however, is not significant. It should be noted that the users of streams and "other" sources of water also show no significant differences in child mortality from mothers who use water which is piped into their own homes. In all subsequent analyses, however, water is categorized only into piped and non-piped sources, for reasons noted earlier.

Toilet facilities: It appears from results in Table 1 that there is a wider differential in child mortality between the best and the worst toilet types than between the different water sources. The worst child mortality is exhibited by mothers whose families have no toilet facilities and must resort to the "bush." Their child mortality is 35 percent higher than average, and is well above the index for mothers who use pit latrines--the group with the next highest index. Nonetheless, when the "bush" category is disregarded, the variation in child mortality across toilet types is relatively modest.

Not surprisingly, mothers whose families use modern flush toilets are associated with the lowest child mortality. Pan toilets appear to be more conducive to child survival than pit latrines and private toilets safer than public ones. Although Iwugo (1981) suggests that the use of pan toilets is the worst form of sanitation in urban Africa, this does not appear to be the case in Ghana. Pan toilets are typically buckets placed underneath wooden or concrete enclosures with a circular hole on the top. The enclosure is either elevated--in which case it serves as a seat--or it is at the ground level--in which case the user squats. Pans are usually emptied on a regular basis, normally nightly. Their major health hazard arises from possible contamination of seats and the spread by flies of human waste exposed in buckets. Pit latrines, generally, are deep holes in the ground which are covered with concrete slabs, wooden planks and/or swish (sun-dried earth) with circular holes provided through the covering slab. Although most pit latrines require the user to squat, some are constructed with elevated covers to serve as seats. Pit latrines are not emptied and a new site is often required when they are filled (see Iwugo, 1981). The major threat to health posed by pit latrines is contamination of the soil and underground water sources, especially when latrines are constructed close to public wells.

When the relationship between toilet facilities and child mortality is examined with controls for other attributes of mothers (Table 2), it is clear that the use of flush toilets

(the omitted category) is associated with lower child mortality risks than all other toilet types. However, the difference between flush toilet users and either private pan or private pit users is not significant. This result suggests that the use of private toilets may be just as important in preventing child mortality as the use of modern flush toilets. Public facilities, on the other hand, are associated with significantly higher child mortality. Public pan users have 7.9 percent and public pit users 12.2 percent higher child mortality than those who use flush toilets. The use of the "bush" is clearly associated with the highest risk of child mortality--15.5 percent higher--and this result is statistically significant beyond the .01 significance level.

B. The relationship between sanitation and child mortality

Water sanitation: The results of the OLS regression in which water sanitation variables are introduced are presented in Table 3, Model 1. Clearly educated mothers who use pipe-borne water have the lowest child mortality. This is not surprising since the results discussed in the preceding section indicate strong child survival advantages associated with the use of piped water. What may be surprising, however, is that the use of piped water is not always associated with lower child mortality. When uneducated mothers use pipe-borne water, they evince a level of child mortality which is 18 percent higher than the

child mortality of educated mothers who use the same facility. Moreover, educated mothers without piped water display a child mortality index which is lower than that for uneducated mothers with piped water, and only 8 percent higher than that for similarly educated mothers with piped water. It is maintained in this paper that this difference is attributable to a usage factor; that educated mothers have better sanitary practices than uneducated mothers.

The results of the regressions pertaining to the sanitation variables are summarized in Table 4. It is clear from this table that the advantage which educated mothers have over uneducated mothers who use the same water facilities is sizable. The relatively high child mortality of uneducated mothers who use pipe-borne water can probably be explained largely by faulty fetching and usage habits. As noted earlier, water is a major channel for the transmission of disease vectors via human waste. If the faucets through which water is supplied or containers with which water is fetched are contaminated, then water, no matter how pure at source, may become contaminated and pose morbidity and mortality threats to children. This is certainly contrary to the assumption of Greenland et al. (1981) that people using water from a common main source share equal contamination risks.

Toilet sanitation: A summary of the regression results(Table 4 and the detailed results in Table 3, Model 2) clearly show that educated mothers and their families compared with uneducated

mothers use toilet facilities in ways which are more conducive to their health and well-being. Large and often significant differences are evident between educated and uneducated mothers across all toilet categories, except modern flush. Moreover, educated mothers whose families use flush toilets have significantly lower child mortality than all others except educated mothers with a private pit, and, as noted above, uneducated mothers with a flush toilet.

The source of the child survival advantage of uneducated mothers who use flush toilets is not clear. The result may suggest, among other things, that flush toilets require minimal care to the extent that even the relatively unsanitary mother faces few health hazards through its use. Alternatively, and perhaps more probably, the use of flush toilets is also associated with several other factors which are conducive to child survival but which are not controlled for in the regressions. One such factor may be higher household income which allows for the purchase of health related goods and services. Among all other toilet sanitation categories, it is clear that the advantage to child survival of better use habits (education) prevails. Even educated mothers who have no toilet facilities and whose households use the bush have only moderately elevated child mortality (12 percent higher than the omitted category), while uneducated mothers with the relatively safer private pans have about 16 percent higher child mortality than the reference group. The difference between the relative child mortality risks of educated bush

users and uneducated private pan users is not statistically significant.

A summary of all the differences in relative child mortality risks which result from changing sanitation status is provided in Table 5. This table shows the percentage point reductions in the child mortality index that would occur if mothers were moved from one combination of education and toilet and water facility to another. Within the lower diagonal of the table, differences are shown only for changes which result in a reduction in relative child mortality risks. Changes which would result in higher relative child mortality are marked by plus signs (+). It will be noted that the largest percentage point declines in child mortality risks usually result from moving mothers from no education to some education. The provision of piped water to uneducated mothers who have none reduces their relative child mortality risks by only a percentage point, while depriving them of piped water but educating them results in a 12 percentage point decline in their relative risk of child mortality. It is clear that providing education without a change in the type of facilities used results in a reduction in the child mortality differential of more than one-half whether water or toilet sanitation is considered.

It should be noted that the distinct advantage in child survival which educated mothers have over uneducated mothers, almost regardless of the quality of toilet and water facilities, is not purely a result of unusually low child mortality risks

among highly educated mothers. Although mothers in the sample with a middle school or higher level of education had, in general, the lowest relative risks of child mortality, mothers with only primary school education maintained a clear and often statistically signfificant advantage in child survival over mothers with no education almost regardless of the quality of facilities they used. Table 6 shows the coefficients of water and sanitation variables which incorporate three levels of education;"none", "primary"(1-6 years of schooling), and "middle"(7 or more years of schooling). The reference group for the toilet sanitation variable is thus mothers with a middle-level education who use flush toilets; that for the water sanitation variable is mothers with a middle-level education with piped water. The coefficients in Table 6 are thus child mortality risks relative to the relevant reference category.

This model suggests that uneducated mothers experience higher relative risks of child mortality than mothers with only primary education--regardless of whether they use piped or non-piped water. Among users of different toilet types, the only case where the relative child mortality risk of uneducated mothers is lower than any of the relative risks of mothers with primary education, is when uneducated mothers use modern flush toilets. These mothers experience lower relative risks than educated mothers who use private or public pit latrines, or the "bushes." All other coefficients for toilet sanitation among uneducated mothers are higher.

5. DISCUSSION

The results of this study strongly suggest that maximization of gains in child survival from the provision of better water and toilet facilities can only be obtained when mothers have some formal education. The provision of piped water, particularly, results in only miniscule reductions in relative child mortality risks for the uneducated. If maternal education accurately represents better usage habits, as has been maintained in this study, then the results suggest that better usage habits are particularly important in the use of water facilities. The findings indicate that only the provision of modern flush type toilets reduces the relative child mortality risks of uneducated mothers to levels comparable to the risks of mothers who are educated. Given that the use of flush toilets requires the existence of piped water facilities, their usefulness as a major option for LDCs--especially in rural areas--is severely limited. But, the provision of as little as a primary education to a mother whose household uses the bush for defecation, results in an improvement in her relative risks of child mortality to a level better than that for uneducated mothers using any toilet type except modern flush.

One major factor accounting for the superior record of educated mothers, almost regardless of the quality of facilities they use, is better hygiene. To illustrate, uneducated mothers whose families use the bush are likely to compromise on how far away from the home defecation should take place, but an

educated mother in the same predicament might be more conscious of the distance from the home necessary to reduce the risk of contamination of household resources. It might be expected that all mothers without toilet facilities would face equally high, exogenously imposed mortality risks. However, it is clear that there are unequal risks at similar levels of sanitation, and it may be wrong to regard the risks as exogenous, that is outside the control of mothers. Educated mothers obviously act in such ways as to reduce potential morbidity and mortality risks to their children.

Another important point to note is that there appears to be a synergism between maternal education and sanitation facilities, such that the relative reduction in child mortality attributable to a joint improvement of maternal education and sanitation facilities exceeds the sum of the relative reduction attributable to improvements in facilities alone and improvements in education status. For example, results in Table 5 show that the provision of piped water to uneducated mothers leads to a 1.1 percentage point reduction in their relative child mortality risks. Educating mothers alone leads to an 11.6 percentage point reduction in their relative child mortality risks. A change in both education and water statuses, however, leads to a 19.3 percentage point reduction in child mortality risks. Similar relationships may be observed for changes in toilet facilities and maternal education. It should be cautioned, however, that since this is a cross-sectional study, and since household income per se has

not been considered, part of this apparent synergism may reflect the greater likelihood that mothers who are both educated and who have good toilet or water facilities, also belong to higher socioeconomic groups.

This study casts light on some important issues of public health concern. By combining demographic and public health variables in an unusual manner, it shows that policies which seek to provide better health conditions solely through improvements in sanitation facilities may achieve less than their desired intent. Instead integrated programs and policies which improve the quality of facilities jointly with education may reap the maximum advantage. In fact, it is clear that education alone, without modern, decent water or toilet facilities, is in most cases more beneficial to child survival than the provision of modern facilities alone. The exact content or duration of such education is not clear. However, this study suggests that even a minimal level of education--in this case 1-6 years of schooling--provides significant benefits. The relative improvements in child survival are clearly greater at higher levels of education.

Table 1. Indexes of Child Mortality in Ghana by Type of Toilet and Water Facilities

Facility	Total CEB to Women in Category	Expected No. of Children Dead	Child Mortality Index
Primary source of water			
Pipe borne water in the house	10456	1999	.5508
Public standpipe	32410	6248	.8228
Rainwater in a tank	755	149	1.0107
Well in the house	3017	585	1.1331
Public well	16389	3187	1.0555
Public dam	2777	541	1.2106
Borehole	1950	377	.8884
Stream/canal	64463	12556	1.0136
Lake pond	4163	806	1.2088
Other sources (not specified)	2047	398	1.0655
Total pipe borne	42866	8247	.7566
Total non-pipe borne	95561	18600	1.0375
Type of toilet			
Flush	4300	819	.5049
Private pan	17211	3307	.6248
Public pan	21686	4182	.8055
Private pit	10139	1962	.8195
Public pit	52857	10280	.9378
Bush	32234	6297	1.3438

Table 2. OLS Regression Results Relating Type of Toilet and Water Facilities to Child Mortality

Variable		B	Standardized beta
Type of Facility:			
Water:	(PIPE)		
	PUBPIPE	.026914*	.009092
	RAIN	.201348	.011831
	PWELL	.149477	.017412
	PUBWELL	.073135	.018850
	DAM	.107311	.012004
	BHOLE	-.019653*	-.001848
	STREAM	.023095*	.009191
	LAKE	.155133	.021138
	ELSE	.071073*	.006844
Toilet:	(WC)		
	PRIVPAN	.021122*	.005560
	PUBPAN	.079342*	.023007
	PUBPIT	.122419	.047449
	PRIVPIT	.069588*	.014464
	BUSH	.154587	.052124
Other Maternal Attributes:			
Mother's Education:	(EDUC)		
	UNEDUC	.142281	.046531
Education of Household Head:	(EDUC)		
	UNEDUC	.018464*	.006671
Religion of Household Head:	(CHRISTIAN)		
	TRAD	.103176	.036073
	MOSL	.156065	.044023
	OTHER	.056793	.014311
Relationship to Head of Household:	(WIFE)		
	THEAD	-.063188	-.007622
	HEAD	-.011596*	-.003245
	DAUGHT	-.097980	-.024060
	OTHREL	-.036677	-.009885
Activity Status:	(HOMEMAKER)		
	WORK	.033345	.012618
	JNMWKD	.017736*	.002278
	UNEMPL	.088413*	.006237
	ELSE	.411846	.025698

Table 2.--Continued

Variable		B	Standardized beta
Type of Residence:	(URBAN)		
	RURAL	.007764	.002799
Place of Birth:	(URBAN)		
	RURAL	.037938	.013720
Type of Kitchen:	(SEPARATE PRIVATE)		
	NOCOOK	-.045966*	-.001990
	SPROOM	.014539*	.005277
	ENWORF	-.006162*	-.001749
	OPEN	.043279	.012282
	BROOM	.041463*	.006657
	ELSE	-.097671*	-.008738
Type of Bath Place:	(SEPARATE PRIVATE)		
	SHROOM	.001958*	.000703
	ENWORF	.063710	.025410
	PUBLIC	-.006322*	-.000779
	RIVER	.159969	.015485
	OPEN	.094494	.017021
	OTHOUSE	.130982	.008287
	ELSE	.150017	.008138
Region of Residence:	(ACCRA)		
	WEST	.229760	.054066
	CENT	.355572	.080086
	EAST	.120490	.032021
	VOLTA	.094153	.022448
	ASHANTI	.166625	.048673
	BAHAFO	.231916	.055684
	NORTH	.419855	.107512
	UPPER	.709415	.178949
	INTERCEPT	.186143	
	R-SQUARE	.0635	

( ) Reference group

*Not significant at the 10% level.

Table 3. OLS Regression Results Relating Toilet and Water Sanitation to Child Mortality

Variable		Model 1 (Using "WATSAN") B	Model 1 (Using "WATSAN") Standardized beta	Model 2 (Using "TOILSAN") B	Model 2 (Using "TOILSAN") Standardized beta
Toilet and Water Sanitation Variables:					
Water Sanitation:	(EDUC/PIPE)				
	NO EDUC/NO PIPE	.192935	.075897	-	-
	NO EDUC/PIPE	.181429	.058269	-	-
	EDUC/NO PIPE	.076509	.018909	-	-
Toilet Sanitation:	(EDUC/FLUSH)				
	NO EDUC/FLUSH	-	-	.075377*	.007103
	NO EDUC/PRIVPAN	-	-	.161687	.032044
	NO EDUC/PUBPAN	-	-	.210335	.053611
	NO EDUC/PUBPIT	-	-	.238733	.088153
	NO EDUC/PRIVPIT	-	-	.171996	.031706
	NO EDUC/BUSH	-	-	.288582	.095861
	EDUC/PRIVPAN	-	-	-.018160*	-.003393
	EDUC/PUBPAN	-	-	.034026*	.005399
	EDUC/PUBPIT	-	-	.111128	.022767
	EDUC/PRIVPIT	-	-	.084190	.008595
	EDUC/BUSH	-	-	.124550	.009725
Other Maternal Attributes:					
Education of Household Head:	(EDUC)				
	UNEDUC	-.017996*	.006502	-.017372*	-.006276
Religion of Household Head:	(CHRISTIAN)				
	TRAD	.105863	.037012	.104582	.036564
	MOSL	.162737	.045905	.163577	.046142
	OTHER	.057215	.014417	.056792	.014310
Relationship to Head of Household:	(WIFE)				
	THEAD	-.007830	-.007830	-.064867	-.007824
	HEAD	-.009113	-.002550	-.008724*	-.002441
	DAUGHT	-.095827	-.023532	-.094303	-.023158
	OTHREL	-.034888	-.009403	-.033407*	-.009004
Activity Status:	(HOMEMAKER)				
	WORK	.033232	.012575	.033008	.012490
	JBNWKD	.015784*	.002026	.016179*	.002078
	UNEMPL	.091948*	.006487	.091646*	.006465
	ELSE	.408031	.025460	.408920	.025513
Place of Birth:	(URBAN)				
	RURAL	.036644	.013252	.036980	.013373
Type of Kitchen:	(SEPARATE PRIVATE)				
	NOCOOK	-.050693*	-.002195	-.048943*	-.002119
	SPROOM	.015292*	.005550	.016012*	.005812
	ENWORF	-.005269*	-.001496	-.005766*	-.001637
	OPEN	.047673	.013529	.049223	.013969
	BROOM	.038484*	.006179	.038886*	.006243
	ELSE	-.102749	-.009192	-.101327	-.009064
Type of Bath Place:	(SEPARATE PRIVATE)				
	SHROOM	-.000841*	-.000302	.000838*	.000301
	ENWORF	.061039	.024344	.062727	.025017
	PUBLIC	-.003377*	-.000416	.007229*	.000890
	RIVER	.150184	.014538	.150436	.014563
	OPEN	.092933	.016740	.093606	.016861
	OTHOUSE	.121919*	.007713	.123518*	.007814
	ELSE	.145507	.007893	.147461	.007999
Region of Residence:	(ACCRA)				
	WEST	.235051	.055311	.241078	.056729
	CENT	.373836	.084200	.377815	.085096
	EAST	.128134	.034052	.135581	.036032
	VOLTA	.101657	.024237	.108109	.025775
	ASHANTI	.165472	.048336	.169551	.049527
	BAHAFO	.236185	.056709	.240784	.057814
	NORTH	.413294	.105832	.419311	.107372
	UPPER	.708516	.178722	.712636	.179761
Source of Water:	(PIPE)				
	NON-PIPE	-	-	.026582*	.009805
Type of Toilet:	(FLUSH)				
	PRIVPAN	.026781*	.007050	-	-
	PUBPAN	.080907	.023460	-	-
	PUBPIT	.121187	.046971	-	-
	PRIVPIT	.064504*	.013407	-	-
	BUSH	.170044	.057336	-	-
	INTERCEPT	.286882		.328855	
	R-SQUARE	.0628		.0629	

( ) Reference group

*Not significant at the 10% level.

Table 4. Summary of Regression Coefficients for Toilet and Water Facilities by Mother's Education

Variable	Educated	Uneducated
Water		
Piped	R	.181429
Non-piped	.076509	.192935
Toilet		
Flush	R	.075377*
Private pan	-.018160*	.161687
Public pan	.034026*	.210335
Private pit	.084190*	.171996
Public pit	.111128	.238733
Bush	.124550	.288582

R Reference category

* Not significantly different from reference category at the 10% level.

Table 5. Percentage Point Reductions in Relative Risks of Child Mortality Associated with Changes in Maternal Education and Facilities

	Mother's Initial Sanitation Status															
	Uneducated								Educated							
	Source of Water		Type of Toilet Used						Source of Water		Type of Toilet Used					
Mother's New Sanitation Status	Non-Piped	Piped	Bush	Public Pit	Public Pan	Private Pit	Private Pan	Flush	Non-Piped	Piped	Bush	Public Pit	Public Pan	Private Pit	Private Pan	Flush
OLS Regression Coefficient	.192935	.181429	.288582	.238733	.210335	.171996	.161687	.075377*	.076509	0.0	.124550	.111128	.034026*	.084190	-.084190	0.0
Water Sanitation:																
Uneducated/Piped Water	1.1*	=							+	+						
Educated/Non-Piped Water	11.6	10.5							=	+						
Educated/Piped Water	19.3	18.1							7.7	+						
Toilet Sanitation:																
Uneducated/Public Pit			5.0	=	+	+	+	+			+	+	+	+	+	+
Uneducated/Public Pan			7.8	2.8*	=	+	+	+			+	+	+	+	+	+
Uneducated/Private Pit			11.7	6.7	3.8*	=	+	+			+	+	+	+	+	+
Uneducated/Private Pan			12.7	7.7	4.9*	1.0*	=	+			+	+	+	+	+	+
Uneducated/Flush			21.3	16.3	13.5	9.7	8.6*	=			+	+	+	+	+	+
Educated/Bush			16.4	11.4	8.6*	4.7*	3.7*	+			=	+	+	+	+	+
Educated/Public Pit			17.8	12.8	10.0	6.1	5.1*	+			1.3*	=	+	+	+	+
Educated/Public Pan			25.5	20.5	17.7	13.8	12.8	4.1*			9.1*	7.7	=	+	+	+
Educated/Private Pit			20.4	15.5	12.7	8.8	7.8*	+			4.0*	2.3*	+	=	+	+
Educated/Private Pan			30.7	25.7	22.9	19.0	18.0	9.4			14.3	12.9	5.2*	10.2	=	1.8*
Educated/Flush			28.9	23.9	21.0	17.2	16.2	7.5*			12.8	11.1	3.4*	8.4*	+	=

*Not significant at the 10% level

=No change in status

+Increase in relative child mortality risks

Table 6. Regression Coefficients for Toilet and Water by Three Levels of Mother Education

Type of Facility	Education: Middle School or Higher	Education: Primary	Education: None	Difference: None-Primary
Toilet				
Flush	R	.194133 (1841)	.230728 (1959)	.036595*
Private Pan	.048864* (805)	.145684 (7258)	.316689 (9147)	.171001
Public Pan	.019955* (187)	.194853 (5524)	.366110 (15973)	.171257
Private Pit	.154659* (81)	.242710 (2224)	.328027 (7834)	.085317
Public Pit	.100862* (208)	.270316 (9618)	.394778 (43031)	.124462
Bush	-.133579* (47)	.295024 (1292)	.444659 (30894)	.149635
Water				
Pipe	R	.116473 (13300)	.289214 (28164)	.172741
Non Pipe	.007260* (429)	.190737 (14457)	.302553 (80674)	.111816

R Reference category

* Not significant at the 10% level

( ) Total CEB to all women in category

Appendix 1. Specification of Independent Variables

Variable	Children ever Born to Mothers in Category	Description
RELIGION OF HOUSEHOLD HEAD: (Reference: "CHRISTIAN")		
TRAD	35,892	Traditionalist
MOSL	20,276	Moslem
OTHER	15,558	Other religions
RELATIONSHIP TO HEAD OF HOUSEHOLD: (Reference: "WIFE")		
THEAD	3,240	Temporary head of household
HEAD	19,892	Head of household
DAUGHT	14,670	Daughter
OTHREL	18,188	Other relationships
ACTIVITY STATUS: (Reference: "HOMEMAKER")		
WORK	91,107	Working
JBNWKD	3,687	Had a job but has not worked recently
UNEMPL	1,091	Unemployed
ELSE	852	Others not in labour force: primarily handicapped
REGION OF RESIDENCE: (Reference: "ACCRA" - capital region)		
WEST	13,326	Western region
CENT	12,089	Central region
EAST	17,589	Eastern region
VOLTA	13,724	Volta region
ASHANTI	22,080	Ashanti region
BAHAFO	13,943	Brong Ahafo region
NORTH	16,144	Northern region
UPPER	15,596	Upper region
TYPE OF BATH PLACE USED: (Reference: "SEPARATE,PRIVATE ROOM")		
SHROOM	39,076	Shared, separate room
ENWORF	70,404	Enclosure without roof
PUBLIC	3,382	Public bathroom
RIVER	2,069	River, stream, lake or pond
OPEN	7,459	Open space around house
OTHHOUSE	876	Another house
ELSE	643	Bush, etc.

Appendix 1--Continued

Variable	Children ever Born to Mothers in Category	Description
TYPE OF KITCHEN USED:		
(Reference: "SEPARATE PRIVATE ROOM")		
NOCOOK	409	No Cooking
SPROOM	40,509	Shared, separate room
ENWORF	20,588	Enclosure without a roof
OPEN	20,575	Open space or structure without walls
BROOM	5,854	Bedroom, living room or veranda
ELSE	1,763	Other house or elsewhere
TYPE OF RESIDENCE:		
(Reference: "URBAN")		
RURAL	98,835	Rural place of residence
PLACE OF BIRTH:		
(Reference: "URBAN")		
RURAL	98,416	Rural place of birth
MOTHER'S EDUCATION		
(Reference: "EDUCATED")		
UNEDUC	108,838	Never completed any level of schooling
MOTHER'S EDUCATIONAL LEVEL		
(Reference: "MIDDLE")		
NONE	108,838	Never completed any level of schooling
PRIMARY	11,289	Completed between 1-6 years of schooling
HEAD OF HOUSEHOLD'S EDUCATION		
(Reference: "EDUCATED")		
UNEDUC	98,551	Never completed any level of schooling
TYPE OF TOILET USED:		
(Reference: "FLUSH")		
PRIVPAN	17,210	Private pan
PUBPAN	21,684	Public pan
PUBPIT	52,857	Public pit
PRIVPIT	10,139	Private pit
BUSH	32,233	Bush, river, etc.

Appendix 1--Continued

Variable	Children ever Born to Mothers in Category	Description
SOURCE OF WATER		
(Reference: "PIPE BORNE WATER IN THE HOME")		
PUBPIPE	32,408	Public standpipe
RAIN	755	Rainwater
PWELL	3,017	Private well
PUBWELL	16,389	Public well
DAM	2,777	Dam
BHOLE	1,950	Borehole
STREAM	64,462	Stream/River
LAKE	4,163	Lake/Pond
ELSE	2,047	Other
WATER AND MOTHER'S EDUCATION (WATSAN):		
(Reference: "COMPLETED ANY LEVEL SCHOOLING WITH PIPED WATER")		
WATSAN 1	80,674	No education/Non-piped water
WATSAN 2	28,164	No education/Piped water
WATSAN 3	14,886	Educated/Non-piped water
TOILET & MOTHER'S EDUCATION (TOILSAN):		
(Reference: "COMPLETED ANY LEVEL OF SCHOOLING WITH FLUSH TOILET")		
TOILSAN 1	1,959	No education/Flush toilet
TOILSAN 2	9,147	No education/Privatepan
TOILSAN 3	15,973	No education/Public pan
TOILSAN 4	43,031	No education/Public pit
TOILSAN 5	7,834	No education/Privatepit
TOILSAN 6	30,894	No education/Bush
TOILSAN 7	8,063	Educated/Private pan
TOILSAN 8	5,711	Educated/Public pan
TOILSAN 9	9,826	Educated/Public pit
TOILSAN 10	2,305	Educated/Private pit
TOILSAN 11	1,339	Educated/Bush

REFERENCES

Bairagi, R. 1980. Is Income the Only Constraint on Child Nutrition in Rural Bangladesh? Bulletin of the World Health Organization 58:767-772.

Barrell, R.A.E. and M.G.M. Rowland. 1979. The Relationship between Rainfall and Well-water pollution in a West African (Gambian) Village. Journal of Hygiene 83(1):143-150.

Behm, H. 1976-1978. La Mortalidad en los Primeros Anos de Vida en Paises de la America Latina.Santiago: Centro Latinoamericana de Demografia. 14 vols.

Butz, W.P., J. DaVanzo, and J.P. Habicht. 1982. Biological and Behavioural Influences on the Mortality of Malaysians. A Rand Note, Rand Corporation, Santa Monica, CA.

Cairncross, S., I. Carruthers, D. Curtis, et al. 1980. Health, in Evaluation for Village Water Supply Planning, Chichester; Wiley.

Cochrane, S.H., D.J. O'Hara and J. Leslie. 1980. The Effects of Education on Health. World Bank; Staff Working Paper #405. Washington, D.C.: World Bank.

Curlin, G.T., K.M.A. Aziz, and M.R. Khan. 1977. The Influence of Drinking Tubewell Water on Diarrhea rates in Matlab, Thana, Bangladesh. Dacca:Cholera Research Laboratory.

Cutting, W.A.M. and P. Hawkins. 1982. The Role of Water in Relation to Diarrheal Diseases. Journal of Tropical Medicine and Hygiene. 85(1):31-40.

Farah, A.A. and Samuel H. Preston. 1981. Child Mortality Differentials in Sudan. African Demography Working Papers Series: 7, Population Studies Center, University of Pennsylvania.

Feachem, R. 1981. The Water and Sanitation Decade, Guest Editorial. Journal of Tropical Medicine and Hygiene 84:47-48.

Gordon, J.E., M. Behar and N.S. Scrimshaw. 1964. Acute Diarrheal Disease in LDC's I, An Epidemiological Basis for Control. Bulletin of the World Health Organization 31:1-7.

_____. 1964b. Acute Diarrheal Diseases in Less Developed Countries III, Methods for Prevention and Control. Bulletin of the World Health Organization 31:21-28.

Gordon, J.E., M.A. Guzma, W. Ascoli, and N.S. Scrimshaw. 1964. Acute Diarrheal Disease in LDC's II, Patterns of Epidemic Behaviour in Rural Guatemalan Villages. Bulletin of the World Health Organization 31:9-20.

REFERENCES--Continued

Greenland, S., R.R. Nuetra, and R. Galan. 1981. An Attempt at Measuring the Impact of Sanitation and Economics on Health: A Re-analysis of the Colombian National Survey. Public Health 95 (5):264-272.

Haines, M. and R. Avery. 1982. Differential Infant and Child Mortality in Costa Rica: 1968-1973. Population Studies 36 (1):31-43.

Iwugo, K.O. 1981. Sanitation technology options for Developing Countries (with special reference to Africa). Public Health 95 (4):189-206.

Khan, M.U., W.H. Mosley, J. Chakraborty, A. M. Sarder and M.R. Khan. 1981. The Relationship of Cholera to Water Use in Rural Bangladesh. International Journal of Epidemiology 10(1):23-26.

Levine, R., M.R. Khan, S. D'Souza, and D.R. Nalin. 1976. Failure of Sanitary Wells to Protect Against Cholera and Other Diarrhoeas in Bangladesh. Lancet 2:86-89.

Meegama, S.A. 1980. Socioeconomic Determinants of Infant and Child Mortality in Sri Lanka: An Analysis of Post War Experience. WFS Scientific Reports 8.

O'Hara, D.J. 1980. Toward a Model of the Effects of Education on Health, in The Effects of Education on Health, World Bank, Staff Working Paper #405. Washington, D.C.:World Bank, 34-55.

Rowland, M.G.M., R.A.E. Barrell and R.G. Whitehead. 1978. Bacterial Contamination in Traditional Gambian Weaning Foods. Lancet 1:136-138.

Scrimshaw, N.S., C.E. Taylor, and J.E. Gordon. 1968. Interactions of Nutrition and Infection. World Health Organization Monograph Series 57. Geneva: World Health Organization.

Stein, J. 1977. Water for the Wealthy. Environment 19(4):6-14.

_____. 1977. Fumbled Help at the Well. Environment 19(5):14-17.

Tawiah, E.O. 1979. Levels, pattern, trends and differentials in Infant and Early Childhood Mortality, Ghana 1960 and 1971. Ph.D. dissertation submitted to Duke University.

Trussell, T.J. and Samuel H. Preston. 1980. Estimating the Covariates of Childhood Mortality from Retrospective Reports of Women. IUSSP Seminar on Methodology for Mortality Analysis, Dakar, Senegal, July 6-10, 1980.

United Nations. 1973. The Determinants and Consequences of Population Trends: New Summary of Findings on Interaction of Demographic, Economic and Social Factors. Vol 1.New York:United Nations.

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